# NC $\pi^0$ Update

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# Definition Change

- Added the additional constraint that no mesons other than $\pi^0$s exit the target nucleus

- Fraction of least restrictive definition (after cuts):

|  | $\nu$ | $\bar{\nu}$ |
|---|---|---|
| $\pi^0$, all mesons | 100% (100%) | 100% (100%) |
| $1\pi^0$, all mesons | 89.8% (96.7%) | 92.2% (97.3%) |
| $\pi^0$, only $\pi^0$ | 94.7% (97.6%) | 95.8% (98.0%) |
| $1\pi^0$, only $\pi^0$ | 85.8% (94.6%) | 88.1% (95.5%) |

# MC Fiducial Volume

- Correcting back to only 500cm now
- MC efficiencies in 500 cm (610.6 cm):

|  | $\nu$ | $\bar{\nu}$ |
|---|---|---|
| $\pi^0$, all mesons | 33.1% (19.0%) | 33.4% (19.2%) |
| $1\pi^0$, all mesons | 35.6% (20.5%) | 35.2% (20.2%) |
| $\pi^0$, only $\pi^0$ | 34.1% (19.6%) | 34.1% (19.6%) |
| $1\pi^0$, only $\pi^0$ | 36.5% (21.0%) | 35.8% (20.6%) |

- The correction used to recover the total rate of events isn't actually the efficiency—it's a psuedoefficiency that also corrects for events with true locations outside the fiducial volume that are reconstructed in the fiducial volume:

$$\epsilon' = \frac{\text{\# of events passing cuts}}{\text{\# of events in radius } r} = \underbrace{\frac{\text{\# of events passing cuts in radius } r}{\text{\# of events in radius } r}}_{\text{Efficiency } \epsilon} \underbrace{\frac{\text{\# of events passing cuts}}{\text{\# of events passing cuts in radius } r}}_{\text{Fiducial Fraction } f_F}$$

- All events passing the reconstructed $500$ cm cut are within $610.6$ cm cut, so when $r = 610.6$ cm, $f_F = 1$ and the psuedoefficiency and efficiency are equal

# Position Dependence of Cross Section Errors

- Cross section errors mysteriously dropped when correcting to 500 cm
- Found I was applying cross section errors to signal events, but also discovered that the cross section normalization error on the MC signal rate was larger in 610.6 cm compared to 500 cm

MultisimMatrix variations of the ratio of the MC rate of RS NC $\pi^0$ signal events in $\bar{\nu}$ mode in 610.6 cm to the rate in 500 cm:
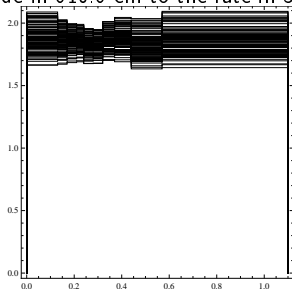


Cross Section
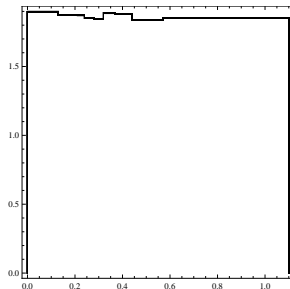


$\pi^+$ Production

This ratio should be constant unless a systematic has a greater relative effect outside 500 cm than in 500 cm.

# Misc.

## Other Changes

- Switched from using Sam's absorber reweighting polynomials to using the AF to do absorber reweighting and using the systematic variation flux files for the integrated flux in each plate config
- Disabled oscillation analysis paremeters in Input_XSec matrix in MultisimMatrix
- Calculated cross sections with systematics for only $\pi^0$ definitions with R-S, Neives, and Alvarez-Ruso coherent production models

## To Do/Doing

- Currently investigating a drop in cross section errors when correcting to 500 cm
- Need to figure out cross section errors for models other than R-S
- Currently implementing Alvarez-Ruso via $E_{\pi^0}(1 - \cos\theta_{\pi^0})$ reweighting; Sam's received new prediction for $p_\pi^0$ and $\cos\theta_{\pi^0}$ that will be implemented soon
- Proofreading technote and reviewing/implementing reviewers' comments